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F3A AC1A2 AC1A3 AC5A AC5D3
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(56) Documents Cited
GB 1084972 A **GB 0852428 A** **WO 80/01511 A**

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INT CL^6 **F42B , F42D**
Online:WPI, EPODOC

(54) Abstract Title
Explosive device for triggering avalanches

(57) An explosive device (10) comprising: an explosive charge body (12) including an explosive charge (14) and detonator (21); a housing (22) attached to the explosive charge body (12); and a length of electrical or non-electrical firing line (26) having a first (28) and second end (32) the majority of which is stored within th housing so as to permit progressive removal from the housing on pulling the first end (28) thereof, and which is attached at the second end (32) to the detonator (21). The explosive device (10) can be used in a versatile manner for avalanche control, can allow a degree of positioning after initial deployment and provide safe operation yet is easily handleable, readily deployed and compact, and negates the hazards associated with the use of pyrotechnic delay fuze. The charge (14) may be a shaped charge.

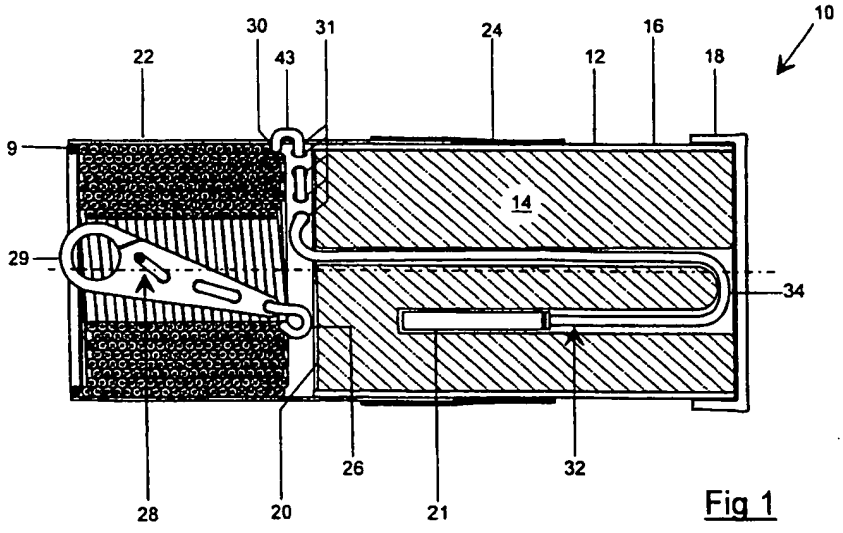

Fig 1

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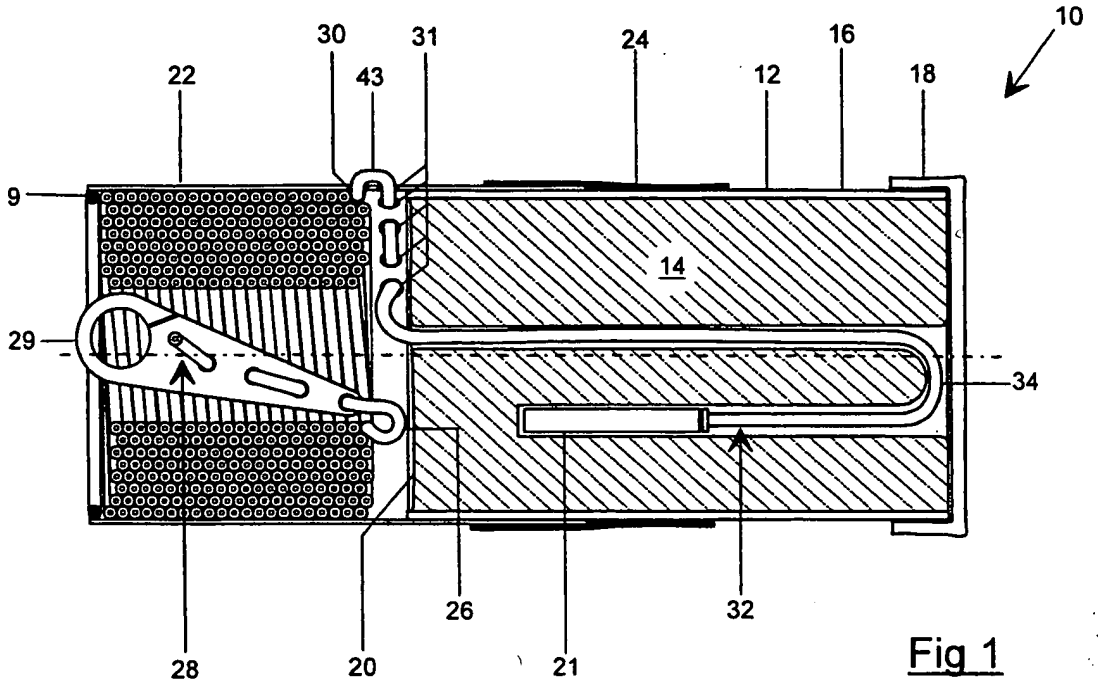
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Fig 1

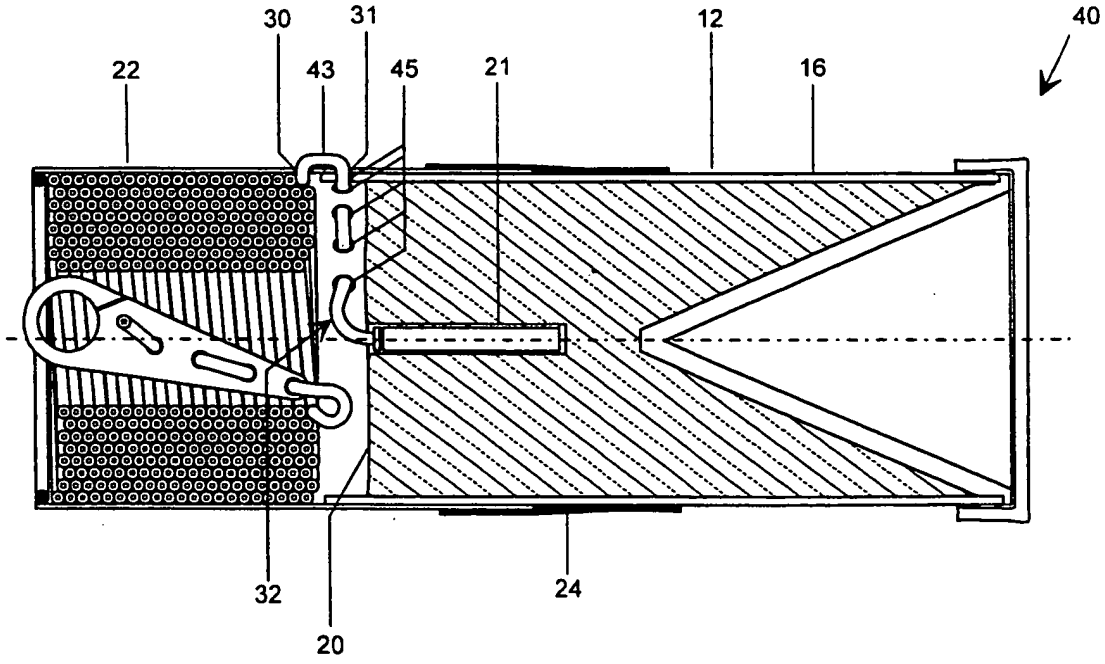
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Fig 2

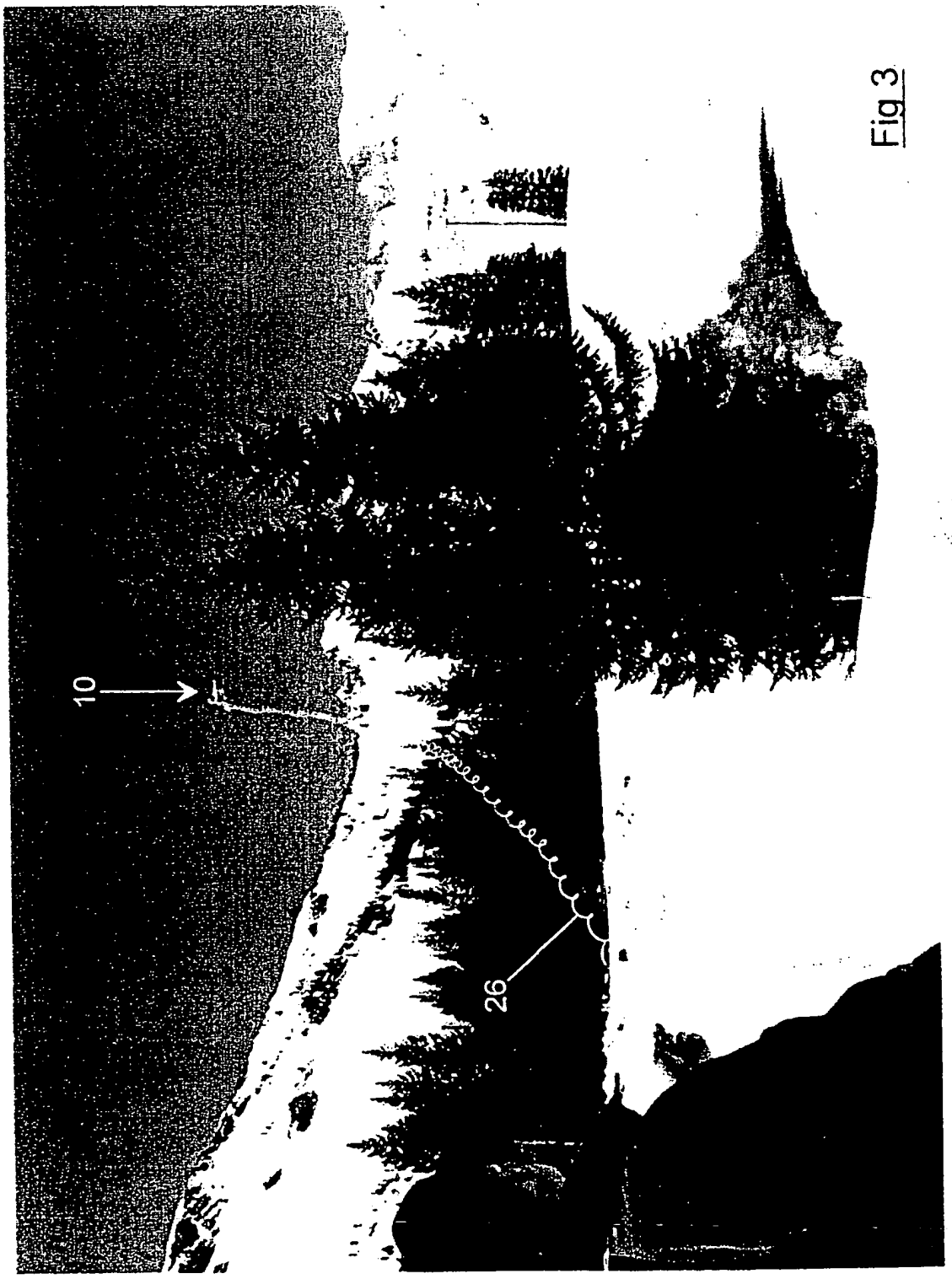

Fig 3

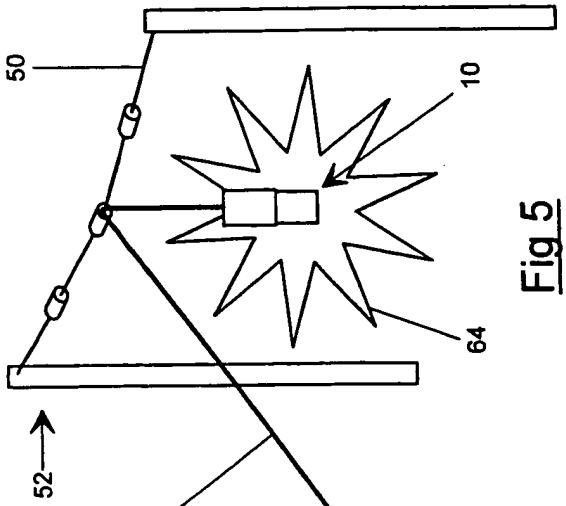

Fig 5

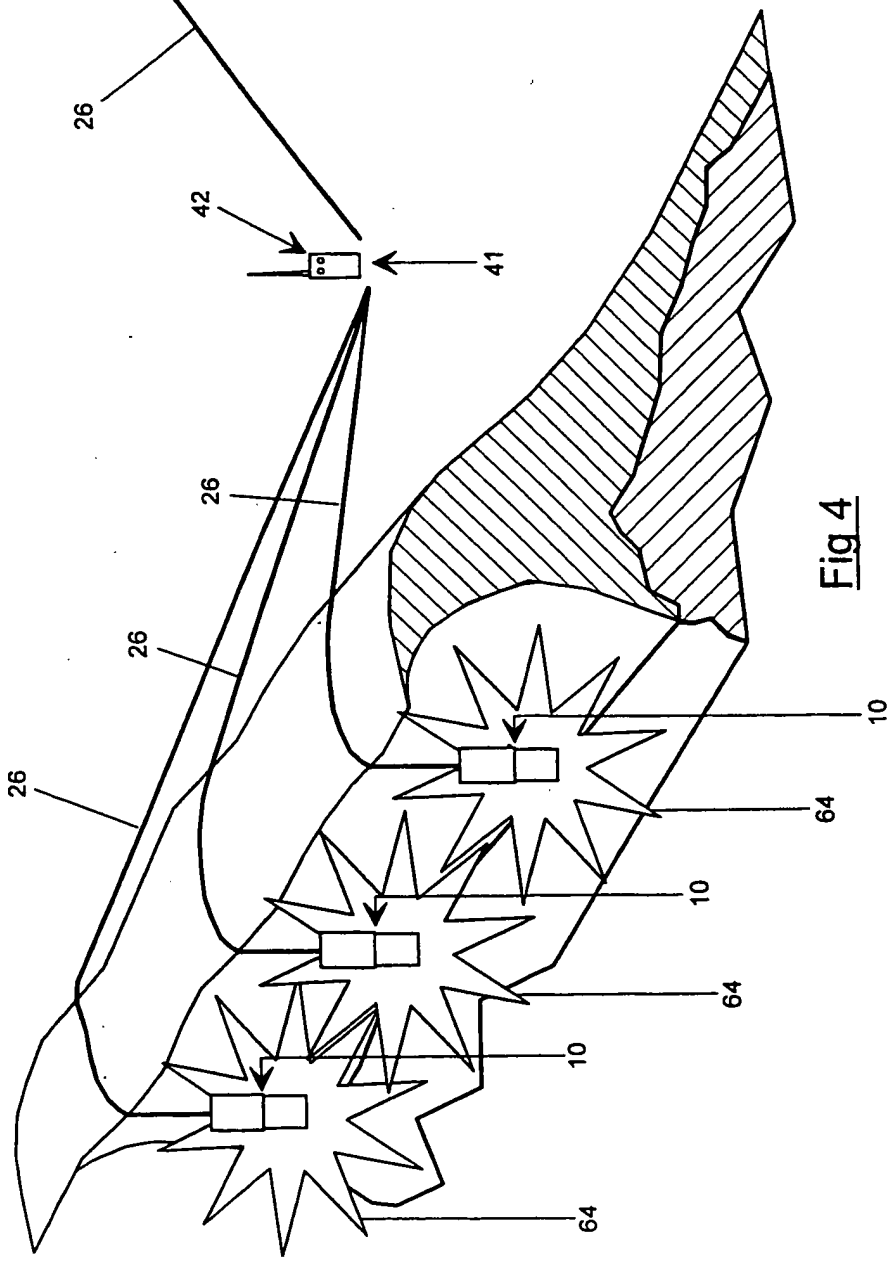

Fig 4

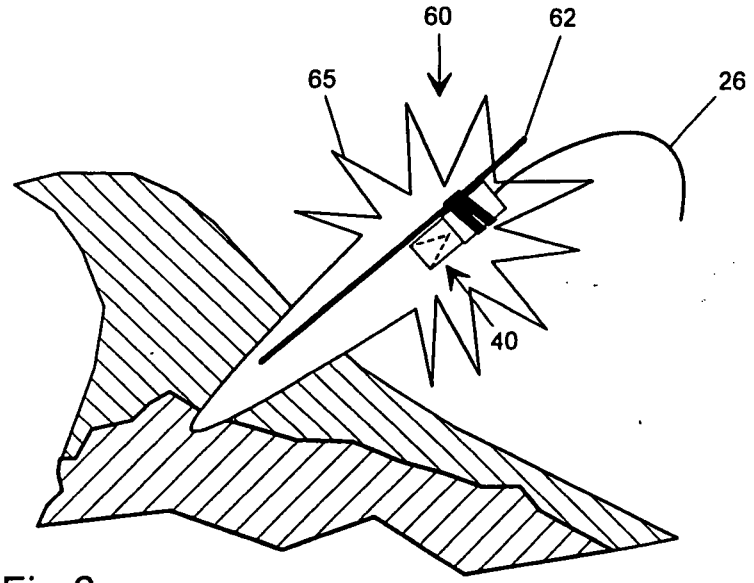

Fig 6

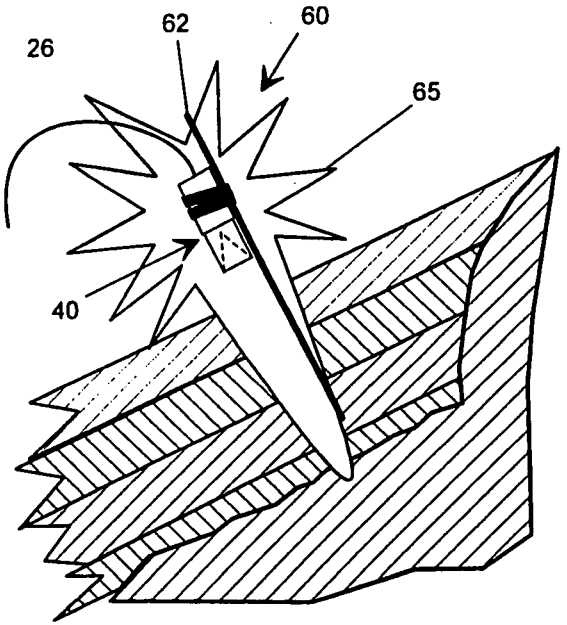

Fig 7

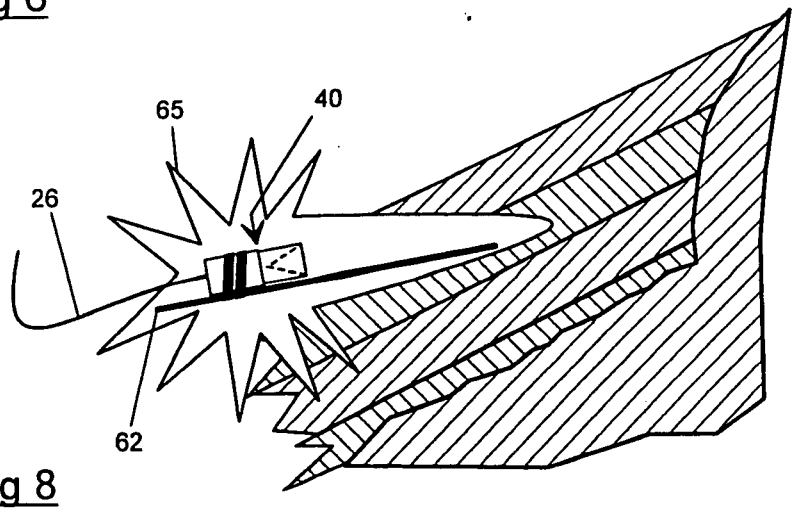

Fig 8

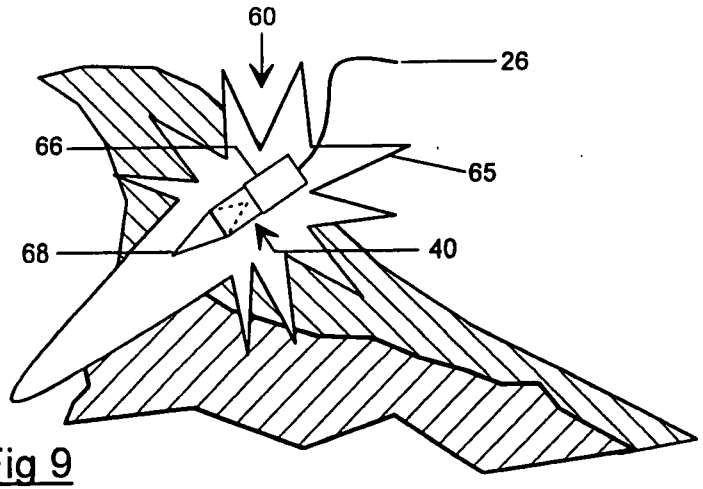

Fig 9

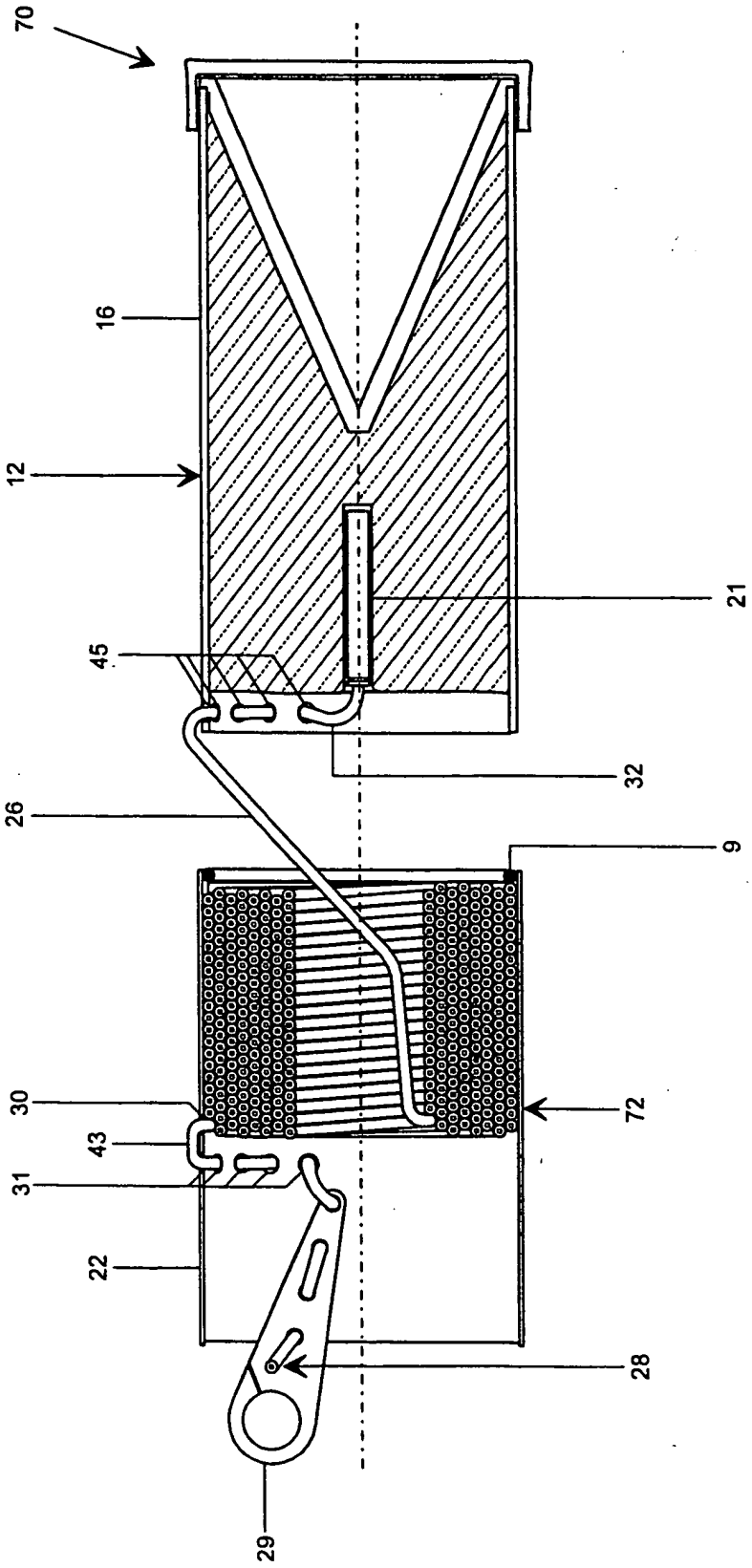

Fig 10

EXPLOSIVE DEVICE

AND METHOD OF USING SUCH A DEVICE

This invention relates to an explosive device and method of using such a device of particular, but not exclusive, application to triggering avalanches in a controlled manner.

Avalanches can present a serious danger to people and property when triggered in an uncontrolled manner, whether by a natural cause such as the weather conditions or unintentionally as a result of human activity such as skiing or climbing. It has therefore become an established practice in many mountainous areas to maintain continuous programme of avalanche control.

Control techniques can be separated into two main categories; passive and active. Two examples of passive control include a preventative approach, with the construction of terraced steel barriers high on the mountain slopes to pin the snow layers and prevent slippage, and a protective approach, where massive ground based deflectors are constructed on lower parts of the mountain to divert avalanche debris from specific structures considered to be at risk. Active avalanche control techniques form part of a carefully organised and continuous process of weather system surveillance, local condition forecasting and a range of practical procedures designed to induce controlled artificial avalanche releases.

This practice of regularly triggering small controlled releases is intended to minimise the build up of snow in known start zones which, if left, would eventually release naturally. Such natural releases of large volumes of snow can cascade to develop massive slides invariably causing extensive damage to services, infrastructure, property and people. People are injured and killed by avalanches every year, world wide.

This invention supports active methods of avalanche control and in particular the use of explosives to stimulate artificial avalanche release. Explosives are used extensively in this role and a wide range of delivery methods are employed to suit the prevailing operational environment. Some of the more common delivery techniques are described below.

Where start zones are inaccessible, the explosive charge can be delivered to the slope in the form of a projectile fired from a gun or mortar system where the projectile explodes on or shortly after impact. Short ranges (2 to 5km) can be covered by gas gun projector systems such as the nitrogen driven avalauncher, used extensively in the US, Canada and Europe. Longer ranges demand high performance systems and military artillery pieces typical of the 105mm howitzer and 106mm recoilless rifles have been used in this role for many years. Accuracy remains a problem for both systems at the limits of their range performance. However, the most significant problem with the military gun systems currently in use is

that the ammunition is now obsolete and ageing.

Although older military ammunition fuzes detonate upon impact (but almost certainly well below the surface in the case of snow pack), in fact, proximity air bursts above the surface produce the most effective avalanche release performance. However, with gun fired projectiles this can only be achieved with electronic proximity burst fuzes. The cost of such fuzing is both inhibitive and notoriously unreliable against light, dispersed mediums such as surface snow, the use of impact fuzing therefore continues. A more recent approach, developed primarily for protection of road and rail routes in remote areas, involves a fixed installation bolted into the mountain side in close proximity to an avalanche start zone. The apparatus, known by its commercial name as Gaz-Ex, consists of a large divergent funnel down which a charge of inflammable gas is injected and ignited using a remote radio command fire management system. The resultant shock wave emitted from the mouth of the funnel then stimulates the controlled release of small avalanches, the frequency being dictated by a combination of local weather surveillance and avalanche forecasting techniques.

Where sites are particularly inaccessible, or have become so due to heavy snow fall or are unsuitable for the use of gun systems and/or the installation of Gaz-Ex systems, helibombing is often employed. Helibombing involves dropping a bag of commercial explosive composition, typically ANFO, into the avalanche start zone

from a helicopter. The charge is detonated via a length of pyrotechnic delay fuze which is ignited in the helicopter before release.

US-A-4,817,529 discloses a method for automatically positioning a blast charge at a predetermined position and height above the snow surface to achieve an air burst from the explosive charge. The charge is suspended below a small hoist. The hoist and charge assembly are attached to a fixed steel cable winch system that traverses the hoist and charge assembly across the slope to the desired firing position. The small hoist is then issued with a command to lower the charge until it senses contact with the snow, and raise it back to a pre-determined height above the snow surface. The charge is fitted with a pyrotechnic delay fuze with a long burn time to allow for the overall positioning sequence to be completed prior to detonation. This fixed system is useful for slopes with a known line of trigger points.

Most areas in ski resorts are accessible, including the mountain peaks, and this accessibility enables explosive charges to be delivered or placed by hand. The practice of hand charge operations is probably the most cost effective and extensively used method of avalanche control in many ski resorts but it carries with it obvious hazards in poor weather conditions. The hand charge is a relatively simple device consisting of a lightly cased (cardboard) explosive charge detonated by a length of capped pyrotechnic delay fuze. The fuze can either be ignited and the charge throwr

into a preferred position or the charge can be pre-positioned above the surface on a bamboo stick before the fuze is ignited. In both cases, *within the delay time*, the operator must retire to a safe position before detonation occurs.

Perhaps the most undesirable characteristic of a pyrotechnic delay fuze is that once the fuze has been ignited the only quick way to de-fuze the device is to attempt to cut the fuze beyond the flame front. This is not acceptable practice, but may be the only option when faced with an emergency. However, once ignited and abandoned, irrespective of circumstances, detonation of the charge cannot be averted. These characteristics together with the difficulty, in adverse weather conditions, of detecting if a fuze has been properly ignited have led to injury and fatalities in the past.

Not surprisingly, more appropriate firing systems have been adopted by the majority of explosive user communities world wide. It is important to recognize, however, that the particularly awkward range of environmental conditions associated with avalanche control operations impose the continued use of pyrotechnic delays fuze pending identification of a satisfactory alternative.

The present invention focusses on avalanche control operations using hand charges. It seeks to provide an explosive device which will extend the convenience and versatility of hand charge control techniques.

The present invention provides an explosive device

comprising an explosive charge body including an explosive charge and a detonator, a housing,

a length of firing line having a first end and a second end, one end operatively connected to the detonator, the majority of which line is stored within the housing so as to permit progressive removal from the housing on pulling one of the ends thereof. The invention allows a degree of re-positioning of the charge after initial charge deployment and provides instantaneous control over the decision to detonate the charge. The explosive device remains easy to handle, readily deployable and compact and avoids the use of the pyrotechnic delay fuze component.

The firing line can consist of two basic types, a twisted pair of electrical conductors for connection to an electric detonator or a non-electric detonation transmission line. The latter is a known alternative initiation system to a slow-burn pyrotechnic fuze or electrical conductor consisting of a firing line of flexible plastics tube with a bore whose inner surface is coated with an explosive composition. It is sometimes referred to as a "shock tube" as the explosive coating is detonated at one end of the shock tube and a detonation shock front propagates down and is fully contained within its interior until it reaches, and so detonates, the reception composition in the detonator cap.

A method of using this explosive device comprises deploying the device at or near a desired location with the firing line extending from the explosive charge to an

initiation site, optionally adjusting the position and/or orientation of the device using the firing line and detonating the explosive charge.

The use of a detonation firing line provides that it is known to the user that there is no possibility of a late detonation in the event of a misfire. Further, the firing line can be chosen to be strong enough to support the weight of the charge so it can be used to retrieve the explosive charge (typically about 1kg in weight) in the event of such a misfire or used to haul the device into a more preferred location prior to the final decision to detonate the charge.

By storing the firing line in a housing in the manner described, the explosive charge can be deployed in a variety of ways including throwing by hand or by a launcher or by hand placing the explosive charge at the desired location and pulling the second end of the firing line to a firing position.

The firing line is preferably coiled within the housing, for example as a series of radially rested helices, to provide ready pulling from the housing. Other storage layering can be used.

Conveniently, an end of the firing line is attached to a tethering clip or tag to make it easier to grip in the hand or attach the end to a fixed anchor.

The firing line may extend from within the housing and be fixed releasably to the outside of the housing or explosive charge body for convenience of handling prior to use and readying the device for deployment.

The housing may comprise a thin sleeve which is a slide-fit over the explosive charge body and retained in position by a strip of adhesive tape, but other means for storing the detonation transmission line in the device ready for deployment may be employed.

Any conveniently available explosive charge may be used to construct the device, particularly shaped charges, bare blast charges, or various enhanced blast charge configurations.

In the latter two cases, the detonator may be embedded in the explosive charge in a number of different positions to achieve different output effects. In such cases strong tethers would also be attached to the charge body to fix the firing line to prevent snatch being transmitted to the detonator. In the case of the simple bare blast charge the firing line may be passed through the body of the explosive filling and passed back into the detonator cap well.

An elongated support, normally bamboo, may be attached to the explosive charge body to act as a standoff. Such a device may be used by positioning the support in the snow so the explosive charge is fixed in a desired position and, if necessary, orientation. The free end of the firing line can then be pulled to the firing position from where the charge can be detonated.

Alternatively, the device may be hand-launched by the user or launched by any convenient launching device, such as a gas gun, riot gun or cross-bow. This allows the operator to stand well back from an unstable area during the

placement operation.

In another method of use of the present invention, the explosive device is launched so the firing line lies over a horizontal support, for example a cable, the vertical position of the device can then be adjusted by pulling back the firing line until the desired height above the snow is achieved.

Embodiments of the explosive device and methods of using such devices, all according to the present invention, will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figures 1 to 2 are diagrammatic, cross-sectional views of two explosive devices, each according to the present invention;

Figure 3 is a photograph showing a hand thrown deployment of the explosive device of Figures 1 and 2;

Figures 4 and 5 are diagrammatic views of a number of hand-thrown or launched deployments of the explosive device shown in Figure 1;

Figures 6 to 9 are diagrammatic views of further methods of deploying the device of Figure 2; and

Figure 10 is a diagrammatic, cross-sectional view of a further embodiment of the present invention.

Referring to Figure 1, an explosive device 10 has an explosive charge body 12, in this case a D90 hand charge manufactured by Dyno Nobel Americas, USA. It has an explosive charge 14 within a cylindrical case 16 capped at one end by cap 18 having a bare explosive surface at the

other. A detonator 21 is embedded in the charge 14.

A sleeve 22 of thin, waterproofed cardboard, a slide-fit over the case 16, is retained in position on the charge body by a circumferentially extending strip of adhesive tape 24.

A 23m length of 3mm diameter firing line 26 (in this case Nonel Dynoline shock tube) manufactured by Dyno Nobel Americas, USA, is coiled within the housing 22 as a series of radially nested helices. Other lengths may be used as required, typically 15 to 30m. A first end 28 of the shock tube 26 extends from the last internal coil and terminates at an anti-snatch tag 29 to which it is secured. This first end 28, when assembled, is located, for transit purposes, inside the space within the shock tube coils. The second end 32 of the shock tube 26 extends from the detonator 21 to a recess 34 in the charge near the cap 18 and then loops back towards the open end of the charge filling 20. From there it passes radially outward to pass through a series of circumferentially spaced securing holes 31 in the housing 22, before looping back into the interior of the housing 22 through hole 30 to start the outer helix of the coiled shock tube 26.

The coiled shock tube assembly is a push-fit into the housing 22 but is retained within the housing by a ring 9 fixed to the open end of the housing. The shock tube 26 is readily drawn from the housing 22 by pulling the tag attached to its first end 28 which can then be attached to a fixed anchor, to the operator or to the launcher system

before launch of the complete assembly 10 to its desired location. The tag is optional.

Referring now to Figure 2, an explosive device is as that of Figure 1 except the bare blast charge body is replaced by a shaped charge explosive body 40 of known type. Those parts in common with Figure 1 have been given the same reference numerals.

In this case the detonator is positioned on the axis at the open end of the charge 20 and the second end of the shock tube passes through a series of holes 45 in the casing 16 and aligned holes 31 in the housing 22 before looping back through hole 30 in the housing 22 to the interior of the housing 22.

It will be clear the present invention may be implemented using various types of explosive bodies which can be detonated by use of an electrical or non-electrical firing line.

Figure 3 illustrates one example of a method of deployment of the device of Figure 1. The first end 28 of the shock tube 26 is held by or attached to the operator and the device 10 launched by hand, the shock tube 26 being progressively pulled from the housing 22 of the device 10 during the flight of the device 10. An alternative method of launched deployment is to launch the device 10 using a mechanical or gas driven system whereupon a similar deployment of the shock tube 26 occurs.

Once deployed the shock tube can be pulled to adjust the position and/or orientation of the device 10.

The device 10 can be launched or thrown so the shock tube 26 lies over a horizontal support such as a cable 50 of a gantry 52, as shown in Figure 5, positioned at a desired location. The shock tube 26 can then be used to lift the device to a desired position above the snow slab prior to detonation.

An example of hand-thrown or launched deployment of series of devices of Figure 1 is shown in Figure 4. The devices 10 have been hung over the line of a cornice build up, the shock tube 26 being used to set the depth of overhang of each charge before being tied off at the firing point. The detonators may embody different delays to provide successive detonations from a single initiation stimulus provided from the firing point 41. Omnidirectional blast emission produced by the bare blast charge 10 is shown by a "star" shaped area 64.

In all methods described in this application, the initiation can be carried out by a user using a handset or by means of a remote receiver of a radio command fire system 42, for example, located at the firing point 41.

Figures 6 to 8 illustrate an explosive device 60 which is as device 40 of Figure 2 but with a support stick 62 affixed to it so the device can be positioned and orientated as required on a snow slab. The highly focussed blast emission produced by the enhanced blast charge 40 is shown by the extended "star" shaped area 65. They respectively illustrate the use of the device for cornice overhang removal with the device 60 providing combined air shock and

deep penetration, slab blasting with the device providing combined air shock and deep penetration perpendicular to the snow slab, and slab blasting where the device is orientated to provide superficial disruption of the surface layer of a snow slab.

Figure 9 shows a further embodiment of the present invention for cornice control. The device 66 is as the device 40 but includes a conical end cap 68 to aid penetration into the soft back of the cornice following remote delivery of the device from a short range launcher system.

Figure 10 is a diagrammatic, cross-sectional view of a further embodiment of the present invention which has the same component parts as the device of Figure 1 but the housing 22 has been rotated through 180° and the first and second ends of the shock tube 26 are now connected to the detonator 21 and tag 29, respectively.

The first end of the shock tube 26 is threaded through holes 45 to secure it to the charge case 16, the second end is threaded through holes 31 in the housing 22 to secure it to the housing 22.

This embodiment is used as follows. The explosive charge 12 is launched by any suitable method, as the device of Figure 1, but the housing 22 is retained at the launching point and the shock tube 26 pulled from the housing 22 by the launched explosive charge 12. The tag 29 is again optional and used to aid anchoring the second end, and in this case, also the housing 22, at the launch site.

Variations in design and method of use applicable to the earlier described embodiments may also be adopted with this embodiment, eg a shaped charge may be used.

CLAIMS

1. An explosive device comprising:

an explosive charge body including an explosive charge and a detonator;

a housing;

a length of firing line having a first end and a second end, one end being operatively connected to the detonator, the majority of which line is stored within the housing so as to permit progressive removal from the housing on pulling one of the ends thereof.

2. An explosive device as claimed in claim 1, in which the firing line is coiled within the housing.

3. An explosive device as claimed in claim 2, in which the firing line is coiled as a series of radially nested helices.

4. An explosive device as claimed in any preceding claim, in which the other end of the firing line is attached to a tag.

5. An explosive device as claimed in any preceding claim, in which the other end of the firing line extends from within the housing and is releasably fixed to the outside of the housing or explosive charge body.

6. An explosive device as claimed in any preceding claim, in which the housing comprises a thin sleeve which is a slide-fit over the explosive charge body and is retained in position by a strip of adhesive tape.

7. An explosive device as claimed in any preceding claim, in which the explosive charge is a shaped charge.

8. An explosive device as claimed in any one of claims 1 to 6, in which the explosive charge is a blast charge.

9. An explosive device as claimed in claim 8 in which the detonator is embedded in the explosive charge and the firing line first extends from the detonator away from the housing before it loops back towards housing.

10. An explosive device as claimed in any preceding claim including an elongate support attached to the explosive charge body.

11. A method of disturbing a snow or ice formation, for example to trigger an avalanche, using the explosive device of any one of claims 1 to 10, comprising:

deploying the explosive charge body at or near a desired location with the firing line extending from the explosive charge to an initiation site;

optionally adjusting the position and/or orientation of the explosive charge body using the firing line; and

detonating the explosive charge.

12. The method of claim 11, in which the explosive charge body is hand-launched by the user.

13. The method of claim 11 or 12, in which the explosive charge body is launched by a launching device.

14. The method claimed in claim 11, and using the device of claim 4, in which the tag is attached to an anchor.

15. The method of any one of claims 11 to 14 in which the explosive charge body is launched so the firing line lies over a support, and the step of adjusting the position of the explosive charge body includes pulling the firing line until the device is at a desired height above the snow.

16. The method as claimed in claim 11 and using the explosive device of claim 10, comprising:

positioning the support in the snow so the explosive charge body is in a desired position and orientation;

pulling the other end of the firing line to firing position; and

detonating the explosive charge.

17. The method of claim 16 and using the device of claim 10 as dependent on claim 4, in which the tag is attached to an

anchor carried by the user and the firing line is pulled from the housing by the user moving away from the device.

18. The method as claimed in claim 12 or 13, in which the housing is retained at the launch site and the firing line is pulled from the housing by the explosive charge body when launched.

19. An explosive device substantially as hereinbefore described with reference to the accompanying drawings.

20. A method of triggering an avalanche substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

19

INVESTOR IN PEOPLE

Application No: GB 9915586.3 **Examiner:** R C Squire
Claims searched: all **Date of search:** 22 September 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): F3A

Int Cl (Ed.6): F42B; F42D

Other: Online:WPI, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1084972	HARVEY (see particularly page 3 lines 34-39, 59, 60	1,2
X	GB 0852428	JERSEY (see particularly page 3 lines 15-23)	1,2
A	WO 80/01511A	SCHROCKSNADEL	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.